Fish community associated with *Halophila stipulacea* meadow in the Mediterranean Sea

by

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ABSTRACT. - The fish fauna of a *Halopila stipulacea* meadow was studied in the Peninsula of Maddalena (Eastern Sicily, Italy; Mediterranean). Visual censuses were conducted every three months from October 1998 to July 1999 and from October 2003 to July 2004. Environmental variables for water temperature, salinity and seagrass shoot density were collected on each sampling occasion. A total of 30 fish species from eight families were recorded. Three labrids and sparids, two serranids and one mullid were detected with high frequency of occurrence (> 75%), while *Sarpa salpa, Coris julis, Oblada melanura, Mullus surmuletus* and *Thalassoma pavo* were the most abundant species. Diversity index and density values displayed a distinct seasonal pattern with highest values occurring in summer and autumn. These community variables were positively related to water temperature, but not to salinity and shoot density. Differences were also found in the relationships between the relative abundances of two species (*Oblada melanura* and *Serranus cabrilla*) and water temperature. Multivariate analysis revealed variation in species composition of the fish community throughout the year. The data show that the fish fauna of the *Halophila stipulacea* meadow of the Peninsula of Maddalena was characterised by a seasonal variation of the community structure, probably mainly influenced by the fluctuations of environmental variables. The presence of small and juvenile fishes of a number of species emphasises the potentially important function of nursery exerted by such seagrass systems during the first phases of the life history of several species.

RÉSUMÉ. - Communauté de poissons associée à l'herbier à *Halophila stipulacea* (Méditerranée).

L'ichtyofaune d'un herbier à *Halophila stipulacea* a été étudiée dans la péninsule de la Maddalena (Sicile orientale, Italie, Méditerranée). Des recensements visuels ont été conduits tous les mois d'octobre 1998 à juillet 1999 et d'octobre 2003 à juillet 2004. Les variables environnementales (température, salinité et densité des faisceaux foliaires) ont été collectées à chaque échantillonnage. Un total de 30 espèces de poissons appartenant à 8 familles différentes a été recensé. Trois Labridae et Sparidae, deux Serranidae et un Mullidae ont été recensés avec une haute fréquence d'occurrence (> 75 %), tandis que *Sarpa salpa, Coris julis, Oblada melanura, Mullus surmuletus* et *Thalassoma pavo* étaient les espèces plus abondantes. L'indice de diversité et les valeurs de densité ont montré un schéma saisonnier distinct, avec des valeurs plus hautes en été et en automne. Cette variabilité des communautés a été reliée positivement à la température de l'eau, mais pas à la salinité ni à la densité des faisceaux foliaires. Des différences ont été détectées dans les relations entre l'abondance relative de deux espèces de poissons (*Oblada melanura* et *Serranus cabrilla*) et la température de l'eau. Les analyses multivariées ont révélé des variations dans la composition spécifique de la communauté de poissons au cours de l'année. L'ichtyofaune de l'herbier à *Halophila stipulacea* de la péninsule de la Maddalena est caractérisée par une variation saisonnière, probablement surtout influencée par les fluctuations des variables environnementales. La présence d'individus de petite taille et de juvéniles de nombreuses espèces souligne la fonction de nourricerie potentiellement importante exercée par l'herbier durant les premières phases de l'histoire de la vie de plusieurs espèces de poissons.

Key words. - Fish community - *Halophila stipulacea* - MED - Sicily - Environmental variables.

Seagrass beds are commonly considered one the most productive and architecturally complex systems in the littoral zone on a worldwide scale (Den Hartog, 1970; Wittman, 1984), and they support diversified algal and animal communities (Mazzella *et al.*, 1993; Edgar and Shaw, 1995). Among the marine fauna associated to seagrass meadow, the ichthyological component is very important with a diverse and specialized assemblage and with many juveniles fishes with high commercial interest, that found in the seagrass bed shelter from predators and great abundance of food (Pollard, 1984; Bell and Pollard, 1989).

Along the coasts of the Mediterranean Sea *Posidonia oceanica* and *Cymodocea nodosa* are the phanerogams commonly and more widespread seagrasses with different ecological requirements, structural complexity, seasonal dynamics and distributional depth range (Mazzella *et al.*, 1993). Another endemic species is *Zostera noltii* that live mixed with *C. nodosa* (Mazzella *et al.*, 1993). *Halophila stipulacea* is a little seagrass with a wide ecological distribution and subtropical affinity (Lipkin, 1975). The Indo-Pacific coastal areas represent its natural biogeographical region (Den Hartog, 1970). However, after the opening of Suez

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Canal in 1869 this species was introduced in the Mediterranean Sea (Lipkin, 1975), where its presence was first reported in 1895 off the Cyprus coast (Fritsch, 1895). Thereafter, it successfully spread along the eastern Mediterranean basin coasts (Lipkin, 1975; Kashta and Pizzuto, 1995). It is unclear when *H. stipulacea* first arrived on the Italian coast, although at the end of the 1980’s Villari (1988) first recorded its presence in the bay of Giardini Naxos (eastern coast of Sicily). In the following years this seagrass spread along the Sicilian coasts, and the small surrounding islands (Rindi *et al.*, 1999). An extensive *H. stipulacea* seagrass bed was found in autumn 1997 in eastern Sicily in an area east of Cape Murro di Porco, south of Syracuse (Di Martino, 2001; Di Martino *et al.*, 2006).

Taking into account the fish community associated to vegetated habitat, in the Mediterranean Sea several authors have investigated the ichthyofauna of the *Posidonia oceanica* (Bell and Harmelin-Vivien, 1982; Harmelin-Vivien, 1983; Harmelin-Vivien and Francour, 1992; Francour, 1997; Guidetti *et al.* 1998; Tunesi *et al.* 2006), the most widespread and productive seagrass of this basin (Mazzella *et al.*, 1993), and recently some studies have been conducted to gather information on those associated with other endemic Mediterranean seagrasses, such as *Cymodocea nodosa* and *Zostera noltii* (Bussotti and Guidetti, 1996; Guidetti and Bussotti, 2000). Despite the successful spreading of *Halophila stipulacea* in the southern region of the Mediterranean Sea information on the fish fauna associated with this recent vegetated ecosystem is still unknown.

This paper represents a contribution to the study of the seasonal cycle of the fish community associated with a *H. stipulacea* meadow in the Mediterranean Sea. Our objective are: 1) to describe seasonal structure of the fish assemblage associated with *H. stipulacea*, 2) to evaluate the potential relationships between the fish community variables (species richness, fish density and diversity) and individual fish species density with the environmental variables (water temperature and salinity) and the seagrass shoot density throughout the year and 3) to investigate the presence of juveniles fishes in order to highlight the possible role as nursery area of the studied seagrass.

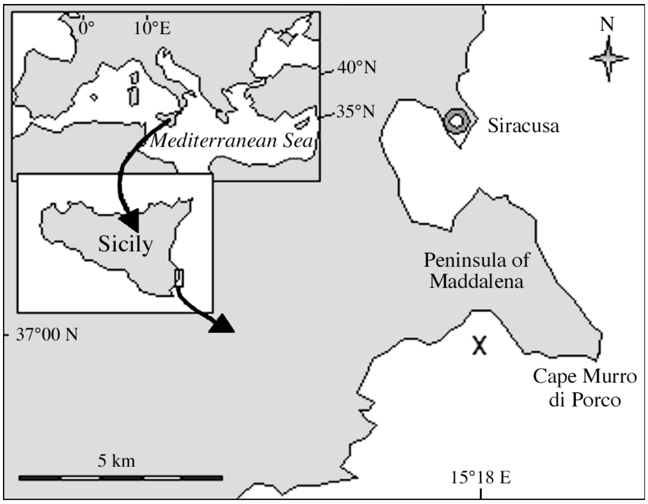

Figure 1. - Study area with sampling site in Sicily, Mediterranean. *[Zone d’étude et site d’échantillonnage en Sicile, Méditerranée.*

MATERIAL AND METHODS

This study was conducted in a sheltered bay southeast of the Peninsula of Maddalena, (Eastern Sicily, Italy: 37°00.232 N; 15°18.835 E, Fig. 1). The *H. stipulacea* meadow lies on a flat bottom at 21 m depth (± 0.5 m) and along the other two phanerogam meadows, running parallel to the coast (*C. nodosa* landward and *P. oceanica* seaward). Water temperature and salinity were measured during each visit. Taking into account that shoot density is considered as one of the best descriptors of seasonal changes in the meadow physiognomy (Mazzella *et al.*, 1993; Marbà *et al.*, 1996) this parameter was measured during autumn 1998 and spring 1999 and autumn 2003 and spring 2004 by counting the number of shoots within frames 30 x 30 cm randomly placed quadrates (nine replicates during each visit) according to Di Martino *et al.* (2000).

Visual estimates of fishes were conducted every three months in two years (three replies during each visit, for a total of 24 visual counts), from October 1998 to July 1999 and from October 2003 to July 2004. Given the habitat heterogeneity we implemented the stationary visual census (hereafter called SVC) throughout our surveys. In this technique the observer locate a position “at random” within the sample area, placing a 5 m long line to serve as a visual reference to estimate the size of the observation area (78.5 m^2) (Tunesi and Vacchi, 1993; Tunesi *et al.*, 2006 and reference therein) and then assumed a position at one end of the line, in three replicates stationary point randomly placed inside of the seagrass bed.

Table I. - Environmental factors and descriptors of meadow physionomy measured in the study area. *[Facteurs environnementaux et descripteurs de la physionomie de l’herbier dans la zone d’étude.]*

	Autumn	Winter	Spring	Summer
Temperature (^oC)	17.4	13.9	15.5	20.0
Salinity	37.8	38.0	38.0	38.1
Longest leaf (horizontal rhizomes)	5.2 cm	-	7.3 cm	-
Longest leaf (vertical rhizomes)	4.2 cm	-	5.9 cm	-
Total number of leafs per m^2	1967	-	1578	-
Length of rhizomes (m/m^2)	36.99	-	20.99	-
Mean length of roots	4.44±0.43	-	3.84±0.26	-
Mean length of internodes	1.15±0.02	-	1.16±0.03	-

Table II. - List of fish species recorded at the *H. stipulacea* meadow. * Species of economical value. F: frequency of occurrence (%); D: no. Individuals 78.5 m^{-2} (mean ± SE); J, S, M, L: Percentage of juvenile, small, medium and large specimens. *[Liste des espèces de poissons recensées dans l'herbier à* H. stipulacea. ** Espèce d'intérêt économique. F : fréquence d'occurrence (%) ; D : nombre d'individus par 78,5 m^2 (moyenne ± erreur strandard); J, S, M, L : pourcentage de juvéniles, petits, moyens et grands specimens.]*

Family	*Species*	F	Mean density	J	S	M	L
Blenniidae	*Blennius ocellaris*	16.7%	2.75 ± 1.37	-	5	67	28
	Parablennius gattorugine	70.8%	1.25 ± 0.22	-	-	53	47
Centracanthidae	*Spicara maena*	4.2%	0.88 ± 0.88	-	-	-	100
Gobiidae	*Chromogobius quadrivittatus*	66.7%	0.92 ± 0.16	-	9	50	41
	Gobius bucchichi	62.5%	1.25 ± 0.26	-	17	60	23
	Gobius geniporus	33.3%	0.46 ± 0.16	-	-	45	55
	Gobius niger	29.2%	0.71 ± 0.27	-	41	59	-
	Pomatoschistus marmoratus	41.7%	0.75 ± 0.20	-	6	72	22
Labridae	*Coris julis*	95.8%	7.00 ± 0.82	-	2	52	46
	Labrus viridis	66.7%	1.92 ± 0.39	-	-	41	59
	Symphodus cinereus	54.2%	1.17 ± 0.27	-	25	43	32
	Symphodus ocellatus	70.8%	1.46 ± 0.26	-	-	74	26
	Symphodus roissali	66.7%	1.54 ± 0.29	-	27	68	5
	Symphodus rostratus	83.3%	2.83 ± 0.38	-	26	52	22
	Symphodus tinca	66.7%	2.13 ± 0.44	-	34	35	31
	Thalassoma pavo	100.0%	3.54 ± 0.21	-	7	86	7
Mullidae	*Mullus surmuletus**	91.7%	3.88 ± 0.47	-	2	57	41
Scorpaenidae	*Helicolenus dactylopterus**	16.7%	0.17 ± 0.08	-	-	100	-
	*Scorpena porcus**	50.0%	0.63 ± 0.15	-	47	40	13
Serranidae	*Serranus cabrilla*	87.5%	2.21 ± 0.32	-	2	64	34
	Serranus scriba	87.5%	1.54 ± 0.20	-	14	40	46
	Serranus hepatus	37.5%	0.38 ± 0.10	-	45	44	11
Sparidae	*Diplodus annularis*	100.0%	2.75 ± 0.33	-	20	77	3
	*Diplodus puntazzo**	54.2%	0.79 ± 0.18	-	10	53	37
	*Diplodus sargus**	62.5%	1.42 ± 0.31	-	32	44	24
	*Diplodus vulgaris**	79.2%	2.17 ± 0.39	29	17	48	6
	Oblada melanura	75.0%	4.33 ± 0.79	-	82	16	2
	*Pagrus pagrus**	41.7%	0.58 ± 0.17	-	36	43	21
	Sarpa salpa	66.7%	9.75 ± 1.57	-	31	56	13
	*Sparus aurata**	70.8%	1.50 ± 0.25	-	17	80	3

Fish were counted on the basis of pre-established abundance classes (1, 2-5, 6-10, 11-30, 31-50, 51-100, 101-200, 201-500, > 500) according with Harmelin-Vivien *et al.* (1985). Fish density (number of individuals / 78.5 m^2) was calculated by taking into account the mid point of each abundance class. The size structure of the fish species recorded was obtained considering four categories, namely juvenile, small, medium and large specimens, on the basis of the fish size (Fisher *et al.*, 1987). Species richness (S), Shannon-Wiener diversity index (H') and percentage of frequency of occurrence of each species were calculated, and the density of most common species, arbitrarily considered as the species showing a frequency of occurrence higher than 75% over both years was also calculated.

Data of density of the recorded species were entered in a species/sampling matrix which was analysed by means of a cluster analysis based on Euclidean distance and the Ward linkage method. Additional analysis such as correspondence Analysis (CA) was conducted on the species mean abundance data matrix to determine association patterns among species and sampling periods. The accepted level of significance was 0.05, verified by means of Lebart's tables (1975). Analysis of variance (two-way ANOVA) was used to test the null hypothesis that there were no differences in the fish density among years and seasons, both considering whole fish assemblage and the most common species. Before each analysis, all data were tested by Cochran's test (for homogeneity of variances) and, whenever necessary, they were appropriately transformed and newly tested (Underwood, 1997). Multiple comparisons *a posteriori* were made by Tukey test. Correlation analyses were used to assess the relationship between environmental variables (water temperature and salinity) and the seagrass shoot density with fish community variables (species richness, diversity, fish density) and the density of most common fish species.

RESULTS

Water temperature at the site varied from 13.9 °C in winter to 20.0 °C in summer. Salinity was lower in autumn and slightly higher in summer, from 37.8 to 38.1 (Tab. I). The *H. stipulacea* plants cover the 35% of total surface in spring and 75% of total surface in autumn. In spring the longest leaf in shoots on horizontal rhizomes measured 7.3 cm, while in vertical rhizomes it measured 5.9 cm. In autumn the longest leaf measured 5.2 cm in shoots on horizontal rhizomes and 4.2 cm in shoots on vertical ones. In spring samples 1578 total number of shoots of leaves per m^2 was found. Total length of rhizomes was 20.99 m/m^2 (Tab. I). The 40% of these shoots lied on vertical rhizomes and the 60% lied on horizontal ones. In this season the mean length (± st. err.) of roots is 3.84 ± 0.26 cm, while the mean length of internodes is 1.16 ± 0.03 cm. The phenological data were collected also in autumn and they show 1967 total number of shoots of leaves per m^2, 88% of which lied on horizontal rhizomes, while 12% lied on vertical rhizomes. In this season the total length of rhizomes was 36.99 m/m^2, the mean length of roots

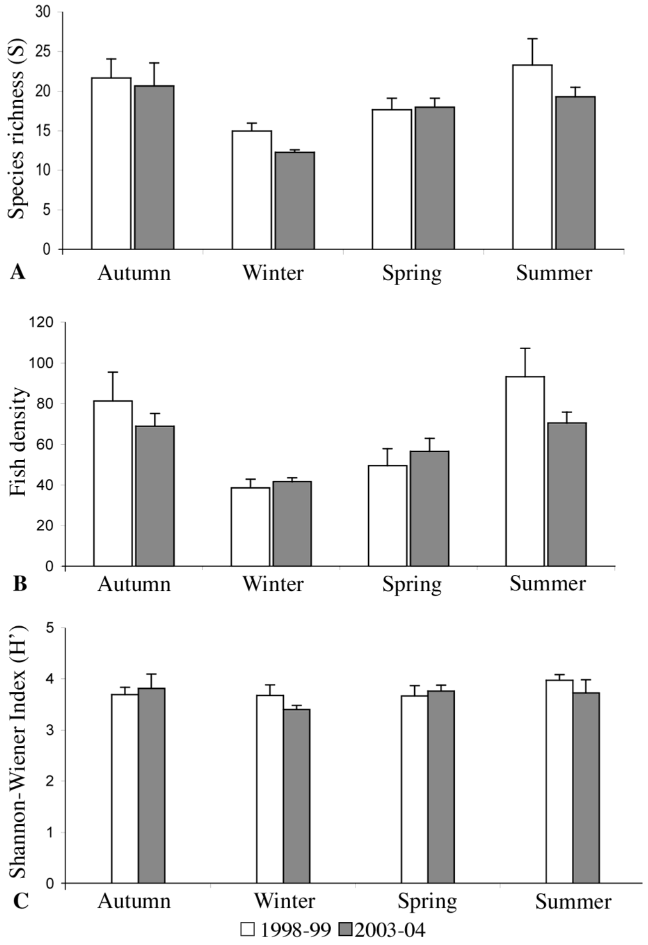

Figure 2. - Seasonal trend of (**A**) the species richness, (**B**) fish density (no. ind./78.5 m^2), (**C**) Shannon-Wiener index (H'), means ± SE. *[Variations saisonnières de (**A**) la richesse spécifique, (**B**) la densité des poissons (nb. d'individus pour 78,5 m^2, (**C**) l'indice de Shannon-Wiener (H') ; moyennes ± SE.]*

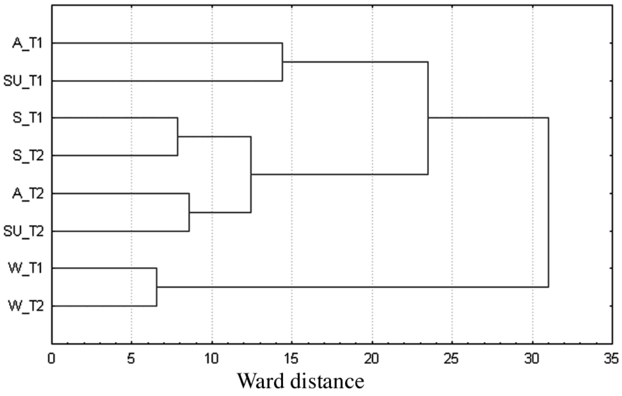

Figure 3. - Dendrogram of cluster analysis on abundance data of fish community detected in each seasons in the two sampling years. *[Dendogramme issu de la classification hiérarchique des données d'abondance des poissons, recensées à chaque saison lors des deux années échantillonnées.]*

is 4.44 ± 0.43 cm, while the mean length of internodes is 1.15 ± 0.02 cm. Only in the autumn we found flowers and it were male flowers, of which the 91% on shoots lying on horizontal rhizomes and the 9% on those lying on vertical ones (Tab. I).

A total of 30 fish species from eight families were recorded during the study period (Tab. II). *Thalassoma pavo* and *Diplodus annularis* had the highest frequency of occurrence (100%) followed by other two labrid species (*Coris julis* and *Symphodus rostratus*), *Mullus surmuletus*, two sparids (*D. vulgaris* and *Oblada melanura*), and two serranids (*Serranus cabrilla* and *S. scriba*), all with frequency of occurrence equal or higher than 75%. Despite *Sarpa salpa* didn't show higher frequency percentage, these fishes were the most abundant taxon, followed by *C. julis*, *O. melanura*, *M. surmuletus* and *T. pavo*. The bulk of the remaining species were less frequent and characterised by lower abundance values. Taking into account the size structure of the fish community, medium size was predominant for 24 species. Among these species, 8 were characterised by an important component of small specimens (> 25%). Only *Scorpaena porcus*, *O. melanura* and *D. vulgaris* was characterised mainly by small and juvenile specimens and *S. maena*, *G. geniporus* and *L. viridis* by large specimens (Tab. II).

The seasonal trends of the species richness shown a significant statistical differences among between seasons (two-way ANOVA, $F = 6.63$ $p < 0.01$) (Fig. 2A) with higher values in summer, for the first sampling year and autumn in the second sampling year, while the lower ones occurred in winter for both years (Tukey test, $p < 0.01$). The total fish density show a distinct seasonal trend (Fig. 2B), with significant statistical differences among seasons (two-way ANOVA, $F = 10.09$ $p < 0.001$), and fish community was particular abundant during the summer and autumn (Tukey test, $p < 0.01$).

There were no significant differences between values of the diversity index calculated for each seasons (two-way ANOVA, n.s.), despite they showed a comparable seasonal trend with fish density, with high values in summer and autumn followed by a decrease in winter (Fig. 2C). Fish density, diversity were significantly and positively related with water temperature ($r = 0.93$, $p < 0.001$; $r = 0.73$, $p < 0.05$), but not to salinity and to shoot density, while the species richness did not show any significant relationship (Tab. III).

The cluster analysis showed a four groups situation (Fig. 3). The winter groups and the samples from summer and autumn'98 appear distinct from the other groups. The others two groups, with the spring samples and samples from summer and autumn '03, were linked with the higher affinity. CA performed on species mean abundance data to analyse fish assemblage composition in relation to sampling time (year and season), points out that the strata points ordi-

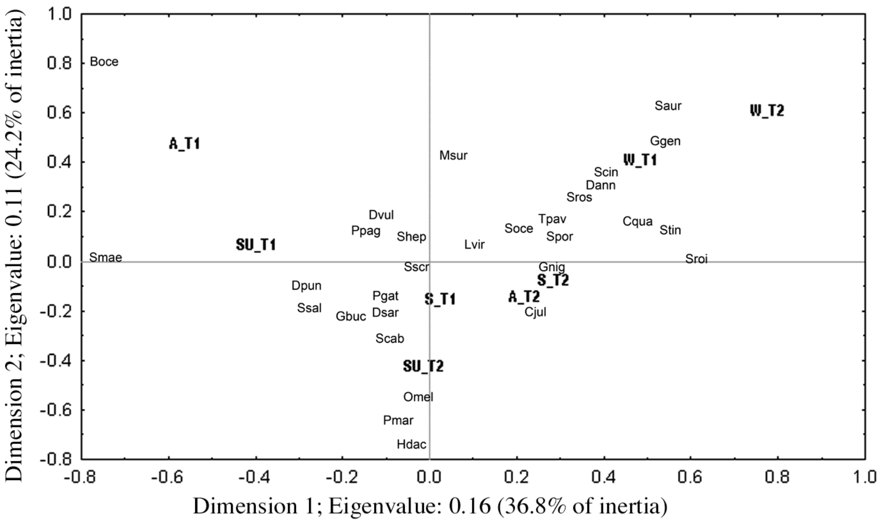

Figure 4. - Results of the CA performed on mean abundance data of fish species detected in each seasons in the two sampling years. *[Résultats de l'analyse des correspondances réalisée sur les abondances moyennes des poissons recensées à chaque saison lors des deux années échantillonnées.]*

Table III. - Correlation coefficients (r) and probability levels (p) computed between environmental variables and shoot density (collected in spring and autumn) with community parameters and density of most common fish species. * p < 0.05; ** p < 0.01; *** p < 0.001; n.s. not significant *[Coefficients de correlation (r) et valeurs de p entre les variables environnementales ou de densité de faisceau (collectées au printemps et automne) et les paramètres des communautés et la densité des espèces les plus communes.]*

Parameters & species	Temperature		Salinity		Shoot density	
	r	*p*	*r*	*p*	*r*	*p*
Species richness	0.59	n.s.	0.16	n.s.	0.32	n.s.
Total fish density	0.93	***	0.15	n.s.	0.40	n.s.
Diversity (H')	0.73	*	0.15	n.s.	-0.60	n.s.
Coris julis	0.58	n.s.	0.50	n.s.	-0.80	n.s.
Symphodus rostratus	-0.28	n.s.	0.31	n.s.	-0.10	n.s.
Thalassoma pavo	-0.20	n.s.	0.00	n.s.	-0.20	n.s.
Diplodus annularis	0.01	n.s.	0.00	n.s.	0.21	n.s.
Diplodus vulgaris	0.10	n.s.	-0.08	n.s.	0.32	n.s.
Oblada melanura	0.88	**	0.46	n.s.	-0.80	n.s.
Mullus surmuletus	-0.10	n.s.	-0.23	n.s.	1.00	n.s.
Serranus cabrilla	0.71	*	0.50	n.s.	0.32	n.s.
Serranus scriba	0.10	n.s.	0.19	n.s.	0.32	n.s.

nation along the first axe identifies a gradient from warm to cold period (Fig. 4), confirming a strong seasonal pattern.

A number of 9 species showed a frequency of occurrence equal or higher of 75% (Tab. II). Among these species only *O. melanura* showed a seasonal pattern similar to those showed by the whole fish community, with no difference among years but significant differences among seasons (Fig. 5D; p < 0.001). On the contrary the density of *S. cabrilla* and *S. scriba* appeared higher in the first sampling year (Fig. 5G, 5H; p < 0.05 and p < 0.01 respectively) and also, *S. cabrilla* was less abundant in winter than in summer (p < 0.01). Finally the density of *Mullus surmuletus* appeared lower only during the spring of the second sampling year (Fig. 5I; p < 0.05). All the other most common fish species didn't show any statistical differences over the years and among seasons.

The density of *O. melanura* and *S. cabrilla* were significantly and positively related with water temperature (r = 0.88; p < 0.01; r = 0.71; p < 0.05, respectively) but not to salinity and to shoot density, while the density of the other most common species (*C. julis*, *T. pavo*, *S. rostratus*, *D. annularis*, *D. vulgaris*, *S. scriba*, *M. surmuletus*) did not show any significant relationship (Tab. III).

DISCUSSION

Most previous research on fish communities associated with Mediterranean seagrasses concerns mainly *Posidonia oceanica* meadows, and with a minor extent *Cymodocea nodosa* and *Zoostera noltii*, while exhaustive studies on fish from allochtonous phanerogam *Halophila stipulacea* is lacking. The fish assemblage associated with *H. stipulacea* was mainly characterised by the presence of sparids, labrids and the important occurrence of strictly benthic species, such as gobiids. The occurrence of benthic species that are commonly found along the continental shelf edge and slope, such as *H. dactylopterus* (Bauchot, 1987a) and *B. ocellaris* a species that live at depth from 30 to 200 m (Bauchot, 1987b) were peculiar of this area. This aspect could be related with the presence in the narrow Messina Strait, with its peculiar geomorphological features and with the presence of narrow rocky bottoms.

Although the scarce occurrence of planktivorous species may differ in the other Mediterranean sea beds, the impor-

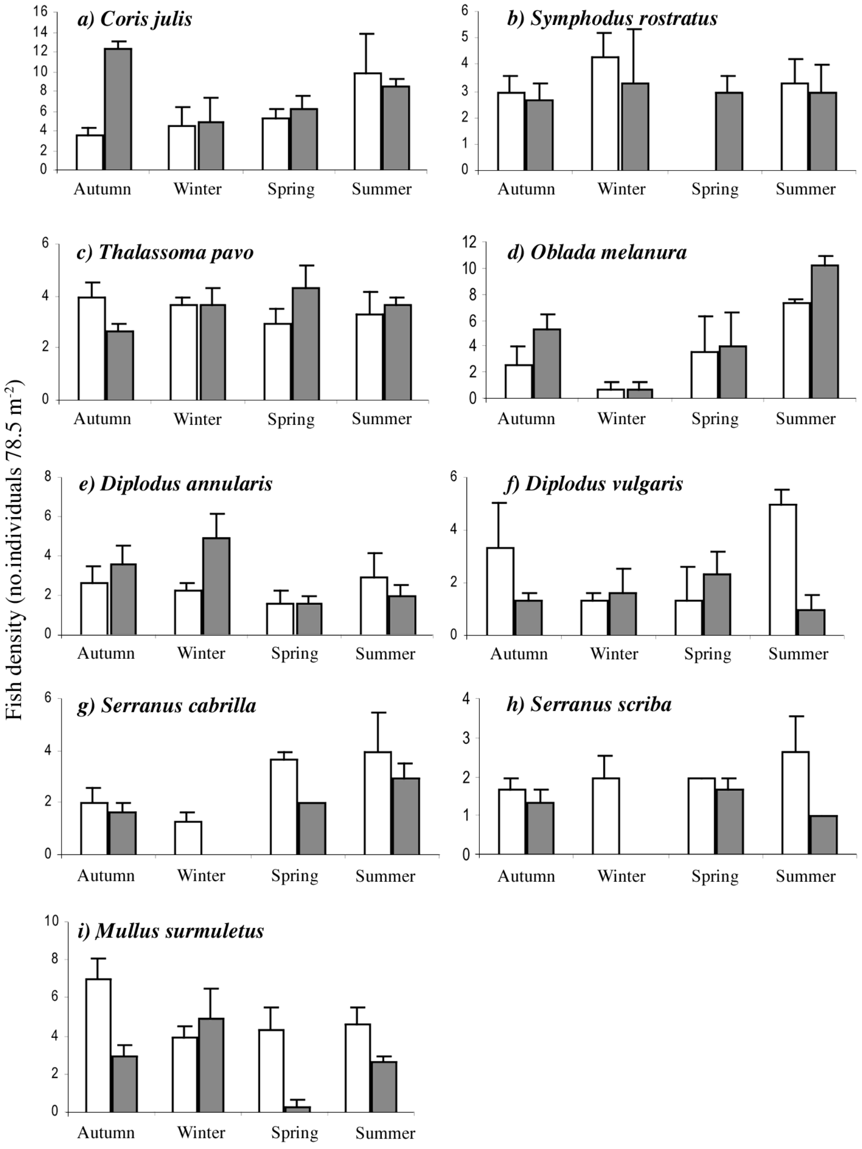

Figure 5. - Seasonal pattern of the mean density of most common fish species. Means ± SE. *[Variations saisonnières de la densité moyenne (± SE) des espèces de poissons les plus communes.]*

tant presence of labrids and sparids could be considered as a common characteristic of fish community of Mediterranean seagrass ecosystems (Harmelin-Vivien and Francour, 1992; Francour, 1997; Guidetti, 2000; Guidetti and Bussotti, 2000; Tunesi *et al.*, 2006). This overall community similarity seems to be consistent with the typical physiology and dynamic of the system considered: *H. stipulacea* maintains a high and comparatively stable structure through the year (Den Hartog, 1970; Di Martino *et al.*, 2000), with a growth relatively independent of seasons, such as *P. oceanica*, while *C. nodosa* and *Z. noltii* are characterised by small size and strong dependence to seasonal forcing (Marbà *et al.*, 1996). It has to be noted that a high number of the species sampled was mainly represented by small-sized specimens. This was the case of *Scorpaena porcus*, *Serranus hepatus*, *Diplodus vulgaris* and *Oblada melanura*, which include some species of economical interest. These results suggest a potentially important function exerted by *Halophila stipulacea* meadow for juveniles of several littoral species in the Mediterranean Sea, as also observed for shallow sheltered *P. oceanica* beds (Francour and Le Direac'h, 1994; Guidetti *et al.*, 1998; Guidetti and Bussotti, 1997), and for seagrass systems composed by *C. nodosa* and *Z. noltii* (Guidetti and Bussotti, 2000).

As reported by several authors warmer seasons are generally considered as the periods of maximum necto-benthic fish abundance and diversity in shallow seagrass habitats (Adams, 1976; Young, 1981) and this in consistent with the positive correlation between the water temperature and the higher diversity and density values of fish community recorded in our study. However the seasonal variation but could be also partially attributed to the availability of more structured complex habitat surrounding the *H. stipulacea* meadow, composed by two areas characterised by *P. oceanica* and *C. nodosa*. Effectively the structural complexity of seagrass beds plays an important role for the fish community structure, in term of predation rate of fish (Orth *et al*., 1984; Bell and Pollard, 1989), higher food availability (Connoly, 1994 and reference therein) and habitat selection by adult and juvenile fish (Williams *et al*., 1990; Connoly, 1994).

Although more data area certainly needed from a higher number of meadows and in several years in order to account for possible variation on larger spatial and temporal scales, such data provide a first description on the fish fauna associated with such seagrass ecosystem and suggest that the fish fauna associated with *Halophila stipulacea* meadow is characterised by high variations through the year with higher species richness and necto-benthic fish densities during the warmer season, and several community variables and the density of two individual fish species are positively associated with water temperature. Moreover also this allochtonous seagrass ecosystem may host juvenile fish during the first phases of their life.

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